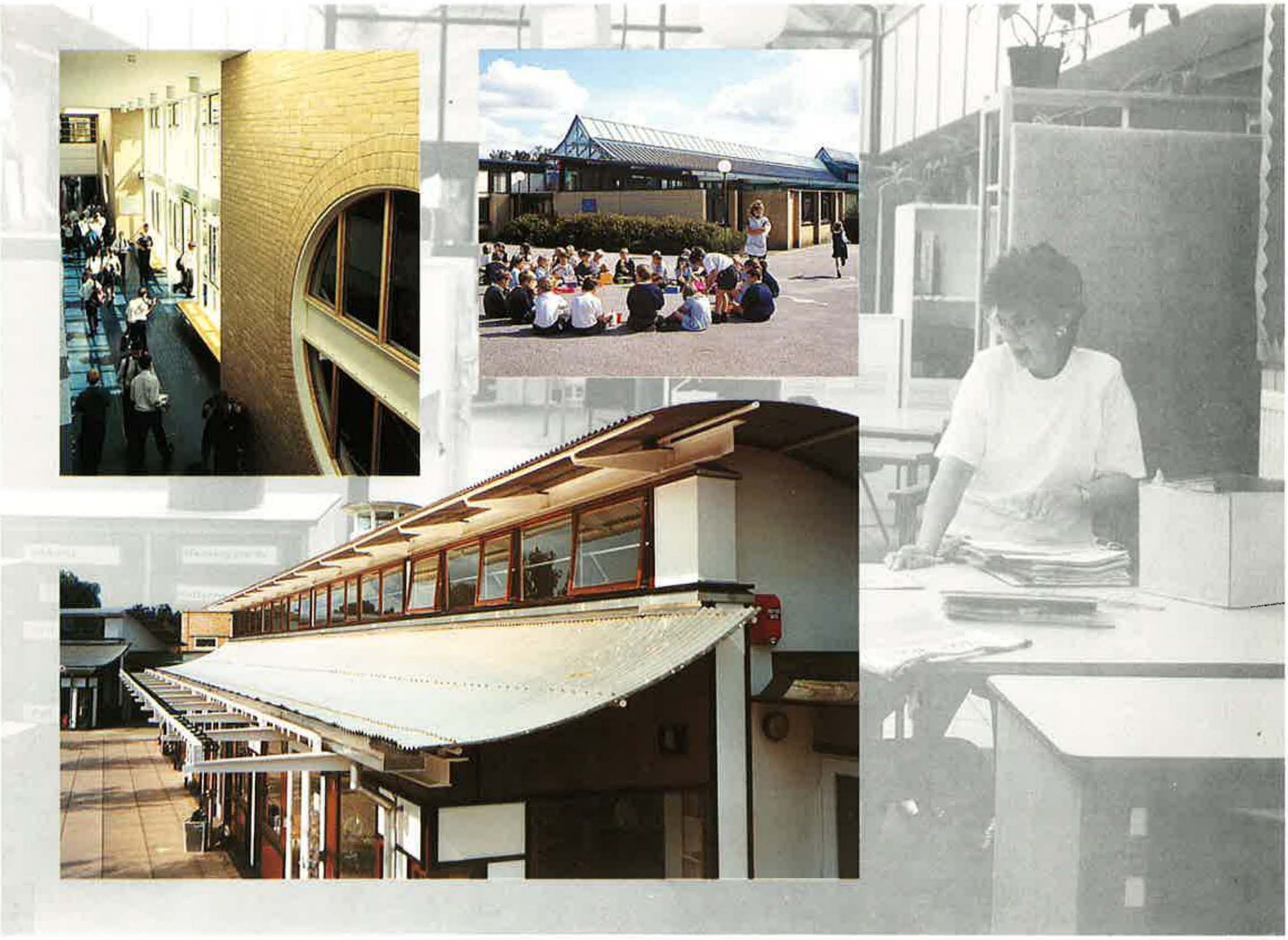
DEPARTMENT OF THE ENVIRONMENT

GOOD PRACTICE GUIDE 173

Energy efficient design of new buildings and extensions

– for schools and colleges



DfEE

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

BEST PRACTICE

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CONTENTS

1 INTRODUCTION

This Guide covers the following key aspects of building design and energy efficiency measures:

- integrated design team
- choice of site, plan form and orientation
- optimising use of daylight
- construction options and impact on energy
- insulation and ventilation
- heating, hot water and controls
- green issues

This Guide is for architects and engineers involved in the design of new school buildings and extensions. It addresses those issues which distinguish school design from that of other buildings, and looks at the way these issues influence energy efficiency at a strategic level. Rather than providing detailed guidance on specific aspects of design, such as environmental services or passive solar techniques, it shows how an integrated design approach – bringing together the skills of a multi-disciplinary team – can lead to energy efficiency.

Much of the guidance is also appropriate to colleges of further education. Accordingly, references to schools and colleges, pupils and students, and teachers and lecturers, are interchangeable.

Schools are intended to provide a comfortable, stimulating learning environment. They are different from other types of building because of their intermittent use, density of occupation and the wide range of activities carried out. Designs that embrace energy efficiency need cost no more to build, and can cost significantly less to run, than more conventional educational buildings. In environmental terms, energy efficient design has considerable benefits for a school and for the wider community, because school premises can have a useful life of sixty years or more.

This Guide is a companion document to 'Guidelines for environmental design in schools'. This is the proposed replacement of the Department for Education and Employment's (DfEE's) Design Note 17 and is currently being drafted.

An insert is included in the pocket at the back of this Guide which provides a summary of the environmental recommendations of the new guidelines. On the reverse of the insert is a summary of the statutory requirements of the Education (School Premises) Regulations 1996 which affect environmental design.

Case studies are also included as loose inserts at the back of this Guide, and the key points are summarised in the table printed on the insert pocket.

Further reading and references are set out in yellow blocks at the end of each chapter.

Hook Junior and Infants School

1

2 DESIGN APPROACH

The key to designing energy efficient schools is the adoption of an integrated design approach. This is best carried out by a multi-disciplinary team – typically an architect, building services engineers, a quantity surveyor and a representative of the client body. Strong inter-disciplinary links and a coherent, iterative approach to the design process should result in a building that performs well in every respect, including energy consumption.

All team members should be involved for the entire duration of the project, from inception to handover. The client's requirements must be clearly identified and any changes to them addressed by the whole team as the project develops. The roles of the various members of the team are outlined in Good Practice Guide 74 'Briefing the design team for energy efficiency in new buildings' (GPG 74), and the points at which important design decisions must be taken are described in British Standard BS8207 and the Royal Institute of British Architects' (RIBA) plan of work.

Integrated design approach

The team's complete understanding of the philosophy of the design should ensure that the correct balance is maintained between educational and energy issues. They must be aware that each school is unique and they must be sensitive to the school's policy for delivering the curriculum.

Particular attention should be paid to the way resources are allocated if the project involves work on an existing site. Concentrating all the available resources on new accommodation to the exclusion of the rest of the school's buildings may not produce the best result in energy terms. It may be more effective to use some of the resources to improve the thermal performance of existing premises and, in so doing, achieve greater overall energy savings and a better internal environment. It is particularly important to ensure that new and existing services are compatible to achieve a good performance.

Designers must be aware that energy efficiency strategies can combine or conflict; individual measures should not be considered in isolation. Their impact on each other, and on the occupants, must be carefully assessed. The cost-effectiveness of proposed energy measures should be demonstrated and expenditure tested against suitable economic criteria.

Education

The main aim of a school is the education of its pupils. A new building should facilitate this process and should itself be an example of an effective use of resources. The layout of teaching areas will vary according to age group, activity and educational practice. Storage requirements are increasing because of the amount of practical work now undertaken. The use of computers, technology benches and scientific equipment has also increased significantly in recent years. So the design process should take into account the changing nature of teaching practice. In the longer term internal spaces may have to be modified and reconfigured. This has implications for energy efficiency, and for the provision of services, which must be addressed as the project develops.

Occupancy

Having established the range of activities to be undertaken in the building, the team must identify the patterns of occupancy that will occur in each space. The density of occupation tends to be much higher in schools than in other types of building. In primary schools a 50 m^2 classroom will accommodate some 30 children, whereas in secondary schools one pupil for every 3-5 m^2 of floor area is typical. The density of occupation and the type of activity undertaken have implications for ventilation, the level of incidental heat gains and design temperatures.

Most schools are in use for six or seven hours a day, with the total annual period of teaching being no more than 1400 hours spread over some 200 days. The buildings will normally be closed at weekends and over the Christmas and Easter holidays and, because of the long summer vacation, will be unoccupied during the warmest weather.

If the school is to be used by the local community outside normal hours, this will affect the design strategy significantly – areas of the building may

DESIGN APPROACH

Section 2 covers:

- *integrated design approach*
- *education*
- *occupancy*
- *flexibility*
- *quality control*
- *maintainability*
- *amenity, health and safety*

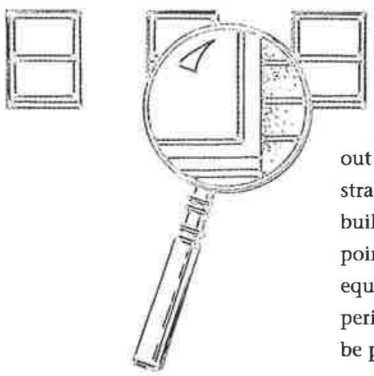
DESIGN APPROACH

need to be operated continuously and independently. For design purposes it should be assumed that even if little out-of-hours community use is foreseen, this situation may well change.

Flexibility

Although it is unrealistic to try to anticipate all of the changes that will take place during a building's life, the design should be sufficiently robust for modifications to be made without adversely affecting the overall heating, lighting or ventilation strategy. If flexibility is a particular requirement then, for example, services should be arranged so that subdivision or enlargement of teaching spaces will be possible.

Controls should be specified which enable the users to heat one or more discrete areas of a school at relatively short notice. The design team should be aware that if controls are too complicated for the intended users they will be overridden, with adverse consequences for energy use and comfort.



Quality control

Quality control procedures should ensure that the design intention is carried out – that close attention is paid to the basic strategies for heating, lighting and ventilating the building, and how they interact. There is little point in specifying energy efficient materials and equipment if they are not installed properly, so periodic inspections of workmanship should be planned.

Maintainability

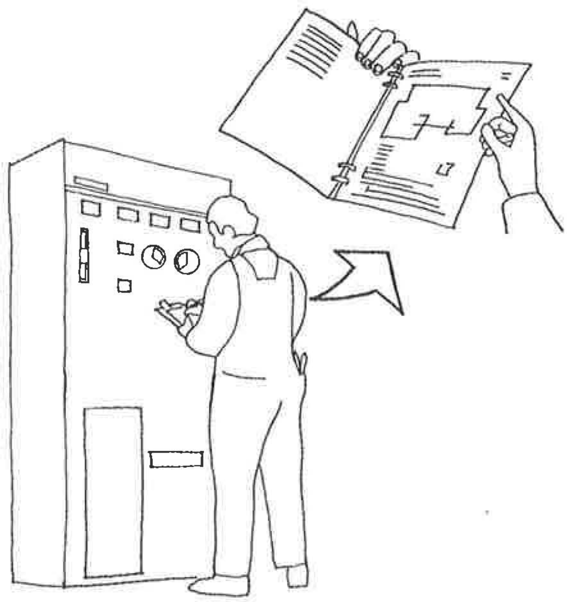
Expenditure on maintenance represents a significant proportion of the operating cost of a school building. Materials and components should be specified which are robust and require the minimum of maintenance. Maintenance also has implications for energy consumption, so the design team should ensure that services requiring regular attention are accessible. Plant room locations and plant space should be estimated at the early stages of the design.

Amenity, health and safety

Energy efficiency should not be achieved at the expense of healthy conditions – ventilation is particularly important. The DfEE lays down the requirements which must be met. Normally, ventilation will be by natural means but in some cases mechanical ventilation may be necessary.

The amenity benefits of a particular approach to a design should also be considered. The best use should be made of views from the windows of schools. Sunlit buildings, particularly those that admit winter sunlight, can provide a much more stimulating environment than those built to exclude the sun.

Noise is a factor often overlooked in school design. Noise levels have risen in urban areas and occupants are increasingly sensitive to it. Naturally ventilated buildings pose a problem in this context, because open windows provide little attenuation. Sometimes the desire for peace and quiet can disrupt the most carefully thought out ventilation strategy. Careful planning should ensure that noise from craft workshops does not intrude into nearby music or drama studios, which, in turn, do not disrupt activities in quiet study areas.



3 SITE AND PLAN FORM

Site

The site can often provide opportunities for energy efficiency and improvements in the amenity of the local environment. If noise and atmospheric pollution are significant then the orientation of the building, its plan form, construction and landscaping will require particular attention.

The duration and extent to which the site is shaded should be investigated, particularly distances and heights of potential obstructions to sunlight. This will identify opportunities for solar gains to the proposed development and will help daylighting design.

Plan form

Currently there is a trend towards compact buildings with central, shared resource areas; the plan form being driven by the need for flexibility within the curriculum. It is relatively straightforward to make buildings of this type thermally efficient but daylighting and ventilation present rather more of a challenge.

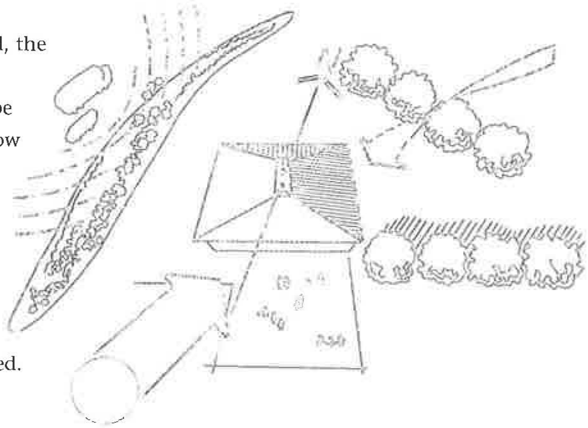
Schools in urban settings sometimes have to be of compact design because of site constraints. In multi-storey school buildings of this type it is possible to introduce ventilation and daylight into the core of the building by using an atrium or lightwell. Each façade needs to be designed for daylight, sunlight penetration and ventilation.

A quadrangle plan is sometimes adopted in dense urban sites; privacy, protection from noise, and control of spacing of buildings are some of the advantages over deep plan designs. There is more exposed envelope but more flexibility for the orientation of rooms.

Buildings in suburban or greenfield areas generally have less constrained sites. The disadvantages of such sites can include increased wind exposure and lower external temperatures. In such cases a shallow plan form can be an attractive design option, because increased levels of insulation and greater opportunities for daylighting and solar heat gains can compensate for the increased heat loss due to the more exposed envelope.

Where the site allows sufficient space between blocks to allow sunlight penetration, it is sometimes desirable to adopt a parallel plan. The blocks can be linked with a corridor or glazed street which provides useful circulation space at minimal cost and without significant loss of daylight, sunlight penetration and ventilation to the buildings.

Whichever plan is adopted, the position and operation of entrances and exits must be carefully considered to allow for draught lobbies and, if possible, protection from the prevailing wind. The high levels of circulation that normally occur within a school must also be accommodated.



Orientation

The influence of solar radiation and the prevailing wind on energy efficiency and comfort should be considered when planning the orientation of a school.

The general rule is that rooms used most frequently should face within 30° of due south, to take advantage of solar gains for heating. North

SITE AND PLAN FORM

Section 3 covers:

- *site*
- *plan form*
- *orientation*
- *passive solar strategies*
- *daylight*

John Cabot College

SITE AND PLAN FORM

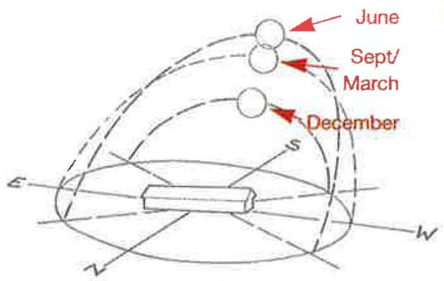
Orientation: school specific issues

Classrooms	S, SE	Medical room	N
Hall, gym, theatre	N, NE	Workshops	N
Toilets	N, NE, NW	Computers	N
Kitchen	N, NE, NW	Circulation	Any
Staffrooms, offices	S, SE	Changing rooms	N
Library, resources	N, NE		

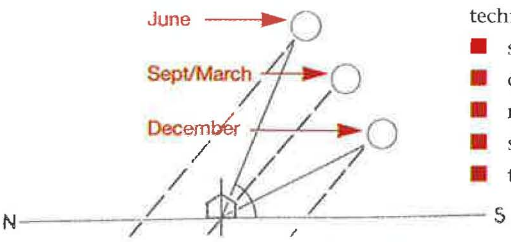
light is preferred for art rooms, and may become the preferred orientation for computer suites because of the absence of direct solar glare. Solar heat gains and solar glare can be particularly unwelcome in workshops.

South-facing vertical surfaces experience about twice as much sunlight in winter as those facing east or west. A south-easterly orientation has traditionally been favoured because it can maximise preheating and reduce summer overheating. An additional advantage is that a corridor can be built on the north-west side of the building which, for many sites, is exposed to the prevailing wind and rain.

Orientation will not directly affect the daylighting strategy, but the effects of any shading to reduce glare or overheating should be assessed in case it reduces daylighting significantly.



Seasonal sunpaths (latitude 53°)



Sun's seasonal altitude (latitude 53°)

Passive solar strategies

In a conventional, ie non-passive solar building, about 10-20% of the total energy demand may be met by adventitious solar gains. By adopting passive solar techniques, within an energy efficient design, as much as 40% of a building's annual energy requirements for heating and lighting can be provided by solar sources. There is a wide range of passive solar techniques, including:

- solar heat gain
- daylight
- natural ventilation
- solar control/shading
- thermal mass.

The solar heating strategy should be simple; designed both to achieve solar heat gains and to control peak temperatures. The aim should be to increase solar gains above those of a conventional building but not to maximise them. The most important design issue is to obtain a positive energy balance for the windows while avoiding overheating and undue glare. Glazed areas of about 40% of the wall area exposed to sunlight provide a reasonable overall energy performance.

The LT Method (a series of algorithms dealing with heat loss and gain) is a design tool which, when used at the earliest design stages, can help to optimise the thermal and daylight performance of windows. The method employs calculation procedures specifically for school buildings.

Solar energy can also be used to augment the natural ventilation of a building – the upward movement of solar heated buoyant air can be used to draw fresh air into the building and provide ventilation on days when there is little or no wind for single-sided or cross-ventilation. Low-level openings must be provided for incoming air and high-level openings (the higher the better) for outgoing air.

Any areas of a building which are solar heated should be zoned so that gains in the spring and autumn can be accommodated within the overall heating strategy. Temperature sensors and controls must be positioned appropriately and be sufficiently responsive to changes in temperature brought about by solar heating.

Such issues should be addressed even for urban sites, or extensions to existing premises. For further information on passive solar design strategies in schools refer to DfEE Building Bulletin BB79 'Passive Solar Schools: A Design Guide'.

Daylight

Daylighting is particularly important in schools because teaching and learning take place more effectively in classrooms that provide good visual quality; and electricity for lighting is a major expense with a significant environmental impact.

SITE AND PLAN FORM

There can be considerable energy savings if daylight is used effectively. Primary schools, in particular, are well suited to the exploitation of daylight because the principal periods of occupation occur during the daytime and most primary schools are single storey where there are a variety of design options – such as rooflights, clerestory lighting, or through-lighting from a central atrium.

Typically, reasonable daylighting can be achieved up to 6-7 m from a window, provided that light-coloured internal surfaces are specified. Where high levels of lighting are required, two-sided lighting is recommended. It is common practice for teachers to display pupils' artwork over windows within classrooms – this reduces daylight levels. Adequate display areas should be provided to discourage this practice. Simple factors, such as keeping walls clear of conduit to enable the fitting of pin-boards can therefore have indirect energy benefits.

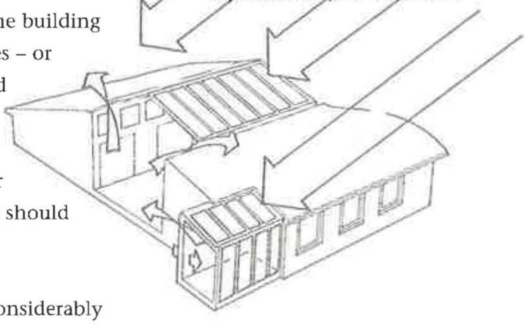
If lightshelves are used with large windows it is possible to achieve an even distribution of light in the classroom and avoid excessive solar heat gains and glare. Window design for daylighting is well documented in, for example, the CIBSE Window Application Manual. Specific daylighting requirements for schools are set out in DfEE Design Note 17 'Guidelines for environmental design in schools'.

Artificial lighting should be used to supplement daylight. The lighting system should respond to daylight levels. Simple user-friendly controls must be introduced otherwise they will be bypassed. Designers should avoid creating a situation where all the lights have to be switched on merely to illuminate part of a room. Manual switches should be located close to the lights they control, and it should be possible to switch on lights furthest from windows independently of those closer to windows.

Atria and conservatories

In addition to providing useful space at low cost, atria and conservatories can be used to provide solar heating, ventilation, daylighting and thermal buffering to adjacent classrooms.

Central atrium at Hook Infants and Junior School



Two common forms of atrium in schools are the courtyard and the glazed street. The courtyard form, in which a glazed roof is added to cover a space between buildings, is especially useful in lowering energy consumption because the overall perimeter of the building to the outside environment is reduced, and the atrium provides a buffer space between the inside and the exterior.

It is often assumed that the inclusion of an atrium or conservatory in a building automatically ensures an energy saving and improved levels of comfort. This is not the case and, unless carefully designed, such a feature may turn out to be extremely wasteful of energy and cause overheating in adjacent areas in the summer.

The design should dictate whether an atrium or conservatory is an integral part of the building to be occupied for educational purposes – or a circulation or intermittently occupied zone – by providing appropriate environmental clues. If these spaces are to be unheated, other than by solar and incidental gains, then their design should explicitly prevent more extensive use.

Light levels within an atrium will be considerably lower than external levels. So, where the atrium is to be used to introduce daylight to adjacent classrooms, larger than normal windows will be required to admit light to these spaces.

The orientation and summer-time ventilation of atria and conservatories are critical if they are not to cause discomfort in adjacent classrooms during hot weather. There must be adequate provision both for the ingress at low level and exit at high level of ventilation air – and this must be achieved without compromising the acoustic separation of the circulation and occupied spaces.

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4 CONSTRUCTION AND BUILDING FABRIC

CONSTRUCTION AND BUILDING FABRIC

Section 4 covers:

- *construction*
- *insulation*
- *ventilation and air-tightness*
- *windows and glazing*

The fabric of a building is often used to influence the thermal response to both solar and internal heat gains, and thereby control the internal temperature swings it may otherwise experience.

- Heavyweight construction gives a slow response, reducing temperature swings from heat gains.
- A lightweight structure has a more rapid response and temperatures may swing excessively.

Heavyweight, well-insulated structure at Walmley School

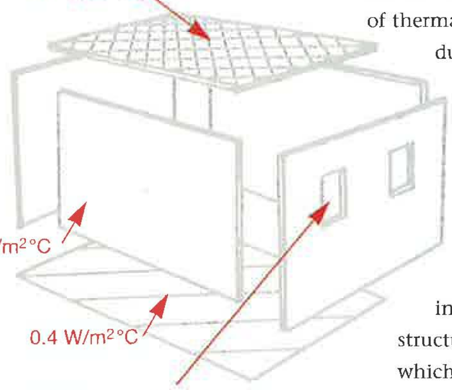
For many school buildings a traditional mediumweight brick and block construction will give the best all-round performance. However, designers may opt for different construction methods if patterns of use and occupancy levels indicate that improved comfort levels and increased energy performance may be the result.

Heavyweight structures require more heat to warm up from cold but, once up to temperature, heat input from the space heating system can be minimal and the rate of cool-down at night is low. Such heavyweight buildings, with their high levels of thermal mass, are suitable for zones used both during and outside normal school hours (such as a community sports facility), but are not appropriate for zones which are occupied and heated intermittently.

Lightweight timber-frame structures offer the designer the opportunity to build-in large thicknesses of insulation. The performance of lightweight structures of this kind is best suited to spaces which are occupied and heated intermittently with moderate internal and solar gains, and may be considered for at least part of the accommodation.

The most appropriate location for thermal mass is inside the insulated envelope of the building fabric, absorbing solar and incidental heat gains during the day and releasing them to the interior space in the evening.

A number of calculation methods can be used to study the environmental performance and effects of thermal mass. The Building Research Establishment Environmental Design Manual provides estimates of summer-time peak temperatures and temperature swings. The admittance procedure in CIBSE's Guide, 'The Thermal Response of Buildings', Volume A, Section 5 can be used for assessing the dynamic performance of a structure. More detailed analysis will require the use of a dynamic thermal simulation program.



DfEE recommended U-values

Insulation

Current practice with conventional building methods, providing mediumweight thermal characteristics, can achieve insulation levels well in excess of the requirements of the Building Regulations. Very high standards of insulation, typically associated with timber frame construction, have been used successfully in a range of building types in the UK, with U-values of 0.24 W/m^2 for walls, 0.20 W/m^2 for floors and 0.12 W/m^2 for roofs. When solar heat gain is controlled and adequate ventilation is provided, concerns over the potential for summer-time overheating have not been realised.

The design team should regard the requirements set out in the proposed replacement of DfEE DN17 as the absolute minimum. An average value for the opaque elements of a school building of 0.35 W/m^2 should be readily attainable.

Ventilation and airtightness

In a well-insulated building, ventilation accounts for a major part of the heat loss, so it is important to eliminate uncontrolled air movement. The design should minimise leaks from fabric, and allow for controlled natural ventilation (see BRE399 and BS5925).

CONSTRUCTION AND BUILDING FABRIC

The DfEE stipulates that all working areas, halls and dormitories should be capable of being ventilated at a minimum rate of 8 litres of fresh air per person per second; and a minimum provision of 3 litres per person per second should be maintained throughout the year.

Natural ventilation is influenced by many factors, such as:

- the occupants opening windows and doors
- the position of doors and partitions within the building
- the location of openings to exterior
- temperature gradients and wind direction.

In most schools ventilation is regulated mainly by the opening and closing of windows. Openable window area should be at least equal to 1/20th of the floor area and the maximum depth of rooms ventilated from one side only should not be greater than 6 m.

Ideally, openings should be provided in more than one face of each room to maximise cross-ventilation. Adjustable trickle ventilators should be incorporated in window units to ensure that the minimum requirement can be met when the windows are closed. As a guide, trickle ventilators with an openable area of 400 mm^2 per m^2 of floor area should provide comfortable background ventilation.

The level of airtightness for schools is not specified, but a standard of no more than 0.3 air changes per hour would seem reasonable. The performance of the final construction can be checked using fan pressurisation.

It is important to ensure that infiltration around window frames is minimised and that windows provide a good seal when closed. In addition, external doors should be draughtstripped and fitted with closers.

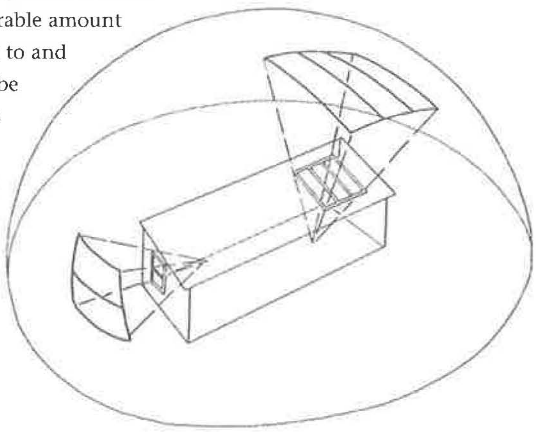
Wherever possible, effective draught lobbies should be specified to minimise the amount of disadvantageous ventilation caused by occupants moving in and out of the building.

Roof lights at St Peter's Primary School, Coggeshall

Windows and glazing

Windows represent one of the most critical areas of school design because, in addition to providing natural ventilation, a window may also have to admit high levels of daylight, solar gains, and the amenity benefits of a view. Designers must ensure that windows are arranged so that discomfort from low-level air movement and solar glare are minimised.

Sash windows are often used in schools because they provide openings at high and low level giving occupants a considerable amount of control of air movement to and from work areas. It should be noted that sliding windows provide only 50% of their glazed area for ventilation.



CONSTRUCTION AND BUILDING FABRIC

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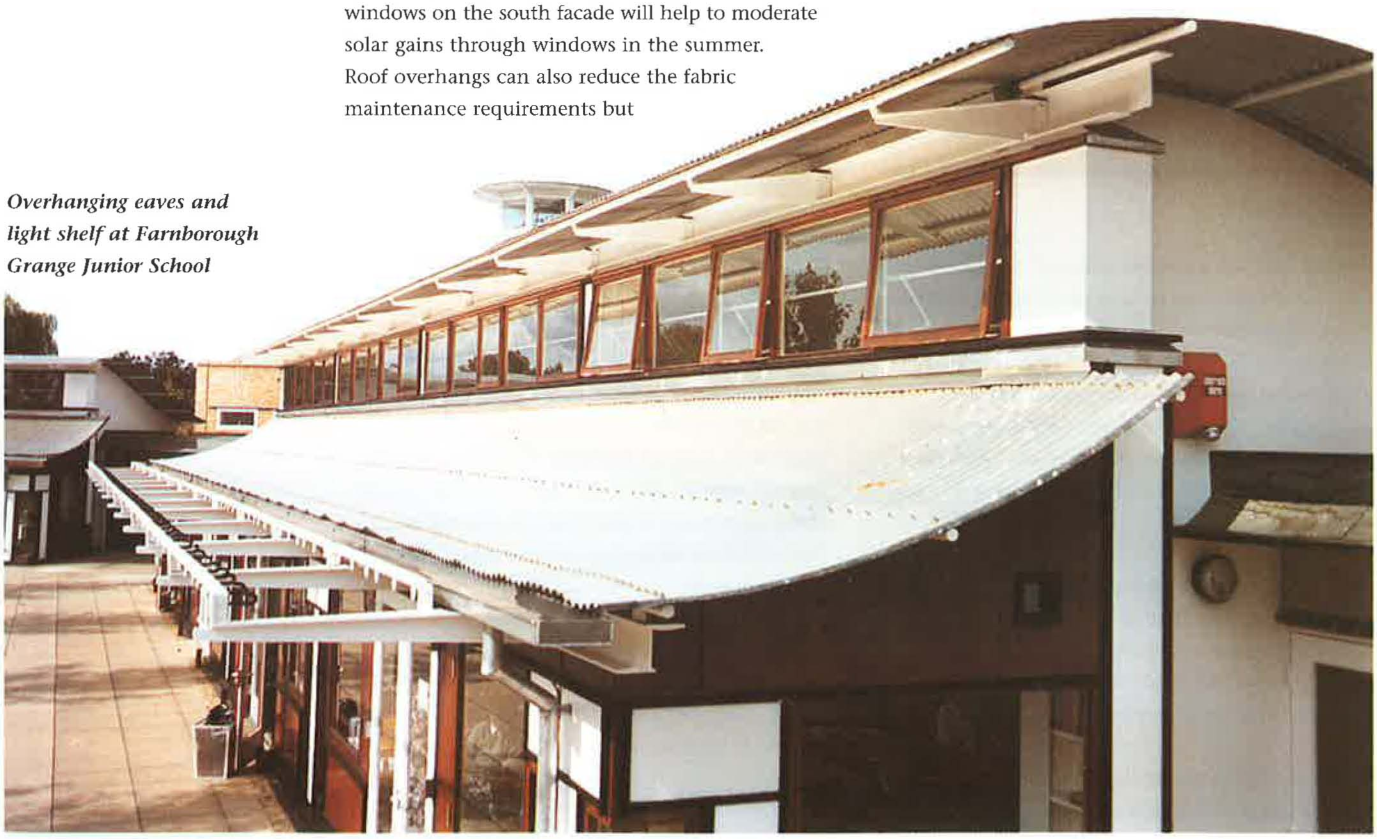
Side-hung casement windows give a greater openable area, but care must be taken to ensure that when fully open they do not present a safety hazard. Fittings must be specified which lock these windows in a background ventilation position and give occupants some degree of fine control.

All glazing should be of the highest thermal performance, and triple glazing may be appropriate for roof lights and north-facing windows. Overly small windows to the north can result in poor daylight and increased use of electric lighting.

Overhanging eaves, external shading or recessed windows on the south facade will help to moderate solar gains through windows in the summer. Roof overhangs can also reduce the fabric maintenance requirements but can reduce the level of daylighting within the building significantly.

Solar control glazing of the windows can be used to limit solar heat gains. However, there is often a reduction in daylight transmission and the 'tint' introduced into the external view is not always liked.

Venetian blinds are often used in schools but, although they keep out unwanted sunlight, they can also impede ventilation and reduce lighting levels to the point where artificial lighting is required.



Overhanging eaves and light shelf at Farnborough Grange Junior School

5 SERVICES

SERVICES

Section 5 covers:

- *space heating*
- *domestic hot water*
- *hot water controls*
- *space heating controls*
- *lighting*
- *mechanical ventilation*

Space heating

Space heating and hot water requirements should be provided with fossil-fuel fired plant rather than electricity. This has lower running costs and generates less carbon dioxide (CO_2). The heating system should have a thermal response which is appropriate for the occupancy pattern, and significant savings can be made if the boiler plant is located to minimise distribution losses.

Ideally, the heating system should allow for change from one type of fuel to another. This will enable the school to take advantage of fluctuations in fuel prices and future changes in fuel availability.

In multiple boiler installations the sequence controller should bring boilers on line automatically to make the system more efficient. Where the output of the lead boiler is greater than 100 kW, a condensing boiler should be considered as the lead boiler.

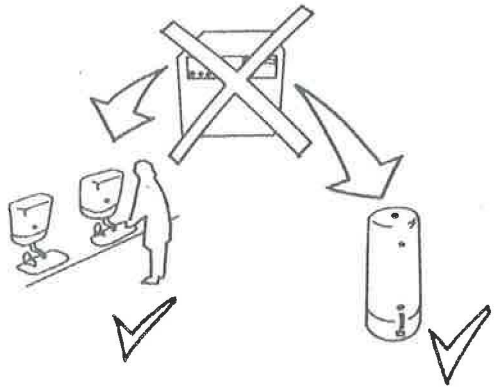
The use of heat pumps to provide space heating should also be considered. An example of their use is the application of air-to-air heat pumps as part of a passive solar design strategy (refer to Roach Vale Primary School, in DfEE Building Bulletin 79). Experience of rural schools away from gas main networks shows that the use of heat pumps can be a cost-effective and efficient option – given a suitable supply, such as ground water, to provide low-grade heat.

Domestic hot water

The hot water system should be independent of the heating system. Where hot water demand is low and infrequent, local hot water heaters should be specified to produce a decentralised system.

Where hot water has to be provided from a central location, such as in kitchens and washrooms, direct-fired gas water heaters can be used to reduce storage. Central hot water storage can be very inefficient where a limited amount of hot water is required.

Where boilers and calorifiers are installed, the equipment should be carefully selected to match



the demand and to give efficient service at part load. They should be located so as to minimise distribution loss, with limited pipe runs and storage capacity.

Hot water controls

Controls, particularly time controls, are an important element of the hot water system because of the intermittent occupancy of school buildings.

Push-button or occupant-sensing operation reduces hot water wastage from taps and showers. Spray taps should be provided on wash basins to reduce hot water consumption. Dead-legs to these taps should be minimised to provide effective use at low draw-off rates.

Legionella bacteria are of special importance, and guidance is available from a number of sources, in particular CIBSE Technical Memorandum 13.

Space heating controls

The simplest controls to meet the requirements of the school and the heating system are likely to be the most successful. The control strategy for the space heating system should be developed from the start of any project.

The DfEE recommends that schools with a heating demand greater than 100 kW should have optimum start control, weather compensation, zoning and individual thermostats as minimum requirements.

For small schools requiring less than 100 kW a simpler boiler installation could be used, provided it has optimum start/stop control and automatic

SERVICES

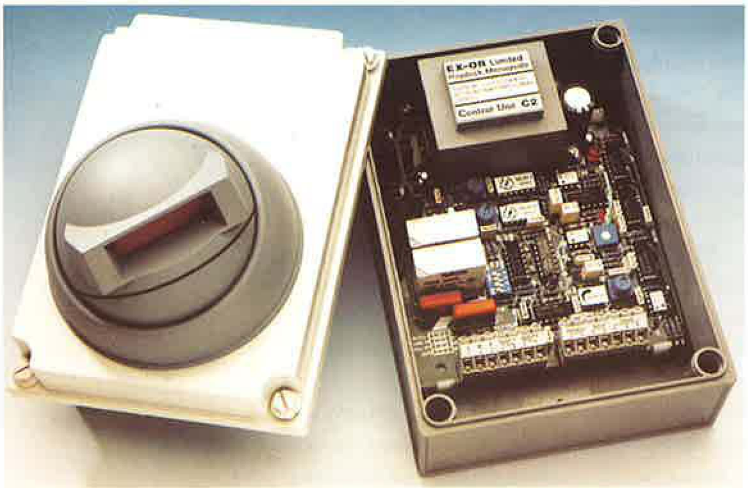
frost protection. Some zoning may be used to account for orientation and pattern of use, and modular boilers may be required. The controls may include a manual override so that heating is available for occasional out-of-hours use.

The design of control systems for larger schools needs careful consideration, as the heating regime will have to be more flexible. Zoning, to control temperatures and the duration of heating within occupied areas, will be a particularly important feature. The position of sensors is critical – this is often a problem if, for example, the zone encompasses areas with different heat gains.

If the buildings have a number of zones they can be linked by a building energy management system (BEMS). BEMS allows the performance and energy use of a building to be monitored continuously. Consumption data can then be used to monitor and target the school's energy performance.

Care should be taken to ensure that the heat load required in zoned areas can be provided efficiently from the heating system, avoiding long distribution runs, and ensuring that boilers work efficiently at part load. In some cases it may be appropriate to use occupancy sensors to switch off the heating.

Frost protection in schools must be carefully considered. It is advisable to keep pipework within



Occupancy sensors are most suitable for larger areas such as assembly and sports halls

the insulated envelope of the building and ensure that the frost protection temperature is set no higher than that required by the DfEE.

Protection of heating systems and building fabric is best accomplished by a three-stage protection scheme based on outside air temperature, pipework return water temperature and internal air temperature. Such a scheme is detailed in Section B11 of the CIBSE Guide, volume B, and variations of the scheme may be employed.

Lighting

The preferred equipment for general lighting in schools is high-frequency fluorescent lamps with high-efficiency ballasts and efficient luminaires. They can be used to provide a uniform illuminance which satisfies most visual requirements for relatively low energy cost. They can withstand frequent switching, and dimming is possible with the appropriate control gear.

Although the initial outlay for incandescent lamps is low, running costs are high so they should be used only where absolutely necessary.

Compact fluorescent lamps are appropriate for circulation spaces and toilets. They consume 20-30% of the electricity required by conventional tungsten bulbs so the capital overcost can be recovered in a relatively short period, typically 1-2 years. Units with control gear separate from the lamp itself should be specified so that replacement costs can be kept to a minimum.

Metal halide, mercury fluorescent and high-pressure sodium lamps (SON) are efficient options for exterior lighting such as car parks and sports facilities. They can also be used for indoor sports facilities and school halls (Good Practice Guide 211 'Drawing a winner. Energy efficiency design of sports centres' (GPG 211)), although due consideration must be given to the control requirements, daylighting strategy and colour rendering.

SERVICES

Suitable lighting controls for schools include a time switch with a manual override for teaching areas, and occupancy sensors in intermittently occupied spaces. If these are used in sports halls then an override must be provided for quiet activities such as examinations, because controls must not disrupt educational activity.

The lighting and its controls should also be designed to take into account community use and the requirements of cleaners and security staff.

For more information on the design of energy efficient lighting for schools consult 'Energy efficient lighting in schools – Maxibrochure', and CIBSE Lighting Guide 5.

Mechanical ventilation

Mechanical ventilation should not normally be required in schools. However, there may be some circumstances in which mechanical ventilation is required to supplement natural ventilation.

According to the DfEE, if ventilation rates higher than 8 litres per second per person are necessary to maintain comfort conditions, supplementary mechanical ventilation may be used. For example, it may be necessary to increase the ventilation rate to maintain the recommended air temperatures in spaces with high functional heat gains, such as kitchens, home economics rooms, or laboratories.

Design Note 29 from the DfEE makes specific recommendations for the construction and installation of school fume cupboards. Additional information can be found in the CLEAPSE Laboratory Handbook and Section B2 of CIBSE Guide volume B.

The DfEE also stipulates that all lavatory accommodation and changing areas in which at least 6 ach (air changes per hour) cannot be achieved by natural means should be mechanically ventilated and the air expelled from the building.

Air may be taken from surrounding spaces, unless the effect will be to increase ventilation of teaching areas beyond that required, in which case a secondary supply of fresh air should be provided.

If openable windows do not provide sufficient fresh air then a passive stack ventilation system should be considered (refer to BRE IP13/94 'Passive stack ventilation systems: design and installation').

FURTHER READING
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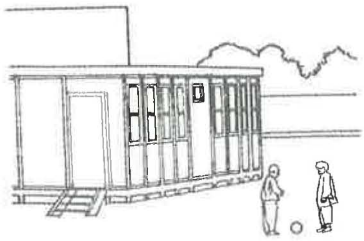
6 TEMPORARY CLASSROOMS

29 If temporary classrooms must be used, the most
30 energy efficient model should be specified. The additional capital costs will be outweighed by lower running costs and improved comfort.

Temporary buildings should have a high level of insulation and be placed in a sheltered part of the school grounds. The internal heating controls should respond to the occupancy.

Refurbishment presents an opportunity to install control systems to reduce energy use significantly. For more information see DfEE Broadsheet 27 'Energy Efficient School Refurbishment - Three Case Studies.'



7 GREEN ISSUES

There are a number of methods of assessing the environmental impact of a new school building. The DfEE's publication 'Schools' Environmental Assessment Method (SEAM)', covers the environmental issues that relate to school design. The aims of SEAM are:

- to raise awareness of the dominant role that buildings play in global warming through the greenhouse effect, and of their role in the production of acid rain and depletion of the ozone layer
- to provide an improved environment for users, including better indoor air quality; and to ensure that products used in the construction are of an environmentally friendly nature, and do not lead to the depletion of non-renewable resources, destruction of the tropical rain forests, or waste resources
- to encourage better use of school grounds and resources for ecology teaching, recreation and recycling.

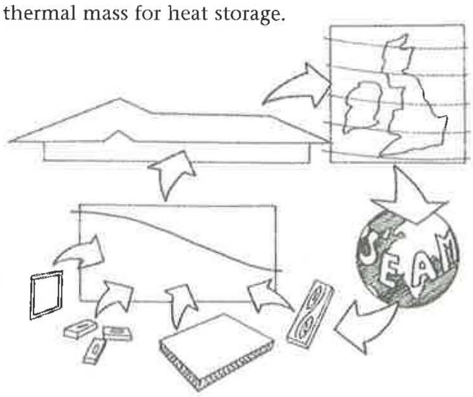
31
32 The Building Research Establishment
33 Environmental Assessment Method (BREEAM) has been developed for a range of building types and,
34 although schools are not included, the method can
35 be applied to their design. Like SEAM, the BREEAM awards credits based on the environmental impact of a building design.

Strategies should be adopted to minimise the energy intensity of a school building. They are likely to include:

- using more wood and less concrete or plasterboard
- specifying fewer plastics and metals - except where lightness, durability and strength are essential
- employing mineral-based insulants rather than polymeric-based materials.

Timber frames can be significantly less energy-intensive than masonry construction if timber from home-grown forestry is used. The manufacture of materials such as chipboard can consume significant amounts of energy.

In general, materials that consume most energy tend to be those used in the greatest quantity by mass, such as cement, plaster products, concrete, blocks and bricks. However, the energy consumed in materials should be evaluated against their life expectancy and their function, such as providing thermal mass for heat storage.



FURTHER READING

1 **Department for Education and Employment**. *Revision of Design Note 17.* Guidelines for environmental design in schools. London, HMSO, (Building Bulletin currently being drafted.)

2 **Department of the Environment**. Briefing the design team for energy efficiency in new buildings, Good Practice Guide 74. London, DOE, 1994

3 **British Standards Institution**. British Standard BS8207, Section 2 and Appendix B. London, BSI, 1985

4 **Royal Institute of British Architects**. LT Method V20, An Energy Design Tool for Non-Domestic Buildings. RIBA, 1994

5 **Department for Education and Employment**. Passive Solar Schools: A Design Guide. *Building Bulletin 79*. London, HMSO, 1994. ISBN 0-11-270876-5

6 **Chartered Institution of Building Services Engineers**. CIBSE Applications manual, Window Design. London, CIBSE, 1987

7 **Building Research Establishment**. BRE Information Papers IP4/92 and IP5/92. Garston, BRE, 1992

8 **Department of the Environment**. Using Solar Energy in Schools, General Information Leaflet 16. London, DOE, 1993

9 **Building Research Establishment**. Thermal Insulation – Avoiding Risks. BR 143. Garston, BRE, 1989

10 **Building Research Establishment**. Environmental Design Manual. Summer conditions in naturally ventilated offices. London, DOE, 1988

11 **Chartered Institution of Building Services Engineers**. CIBSE Guide, Volume A, section 5, The Thermal Response of Buildings. London, CIBSE, 1979

12 **Building Research Establishment**. Natural Ventilation in Non-Domestic Buildings, BRE399. Garston, BRE, 1994

13 **British Standards Institution**. British Standard 5925: Code of Practice for Ventilation Principles and Designing for Natural Ventilation. London, BSI 1991

14 **Building Research Establishment**. Daylight as a Passive Solar Energy Option, BR129. Garston, BRE, 1988

15 **Department of the Environment**. Passive Solar Design. Netley Abbey Junior School, General Information Leaflet 32. London, DOE, 1996

16 **Department of the Environment**. Passive Solar Design. Looe Infant and Junior School, General Information Leaflet 33. London, DOE, 1996

17 **Chartered Institution of Building Services Engineers**. Technical Memorandum 13, Minimising the risk of legionnaires disease. 1991

18 Energy Efficient Lighting in Schools, BRECSU-OPET, Commission of the European Communities DG17, 1992

19 **Chartered Institution of Building Services Engineers**. Code for interior lighting. London, CIBSE, 1994

20 **Department for Education and Employment**. Design Note 29, Fume cupboards in schools. London, DfEE, 1982 (under revision)

21 Laboratory Handbook; Consortium of Local Education Authorities for the Provision of Science Equipment (CLEAPSE), 1988

22 **Building Research Establishment**. IP13/94, Passive stack ventilation systems; design and installation. Garston, BRE, 1994

23 **British Standards Institution**. British Standard BS 8206 Lighting for Buildings; Part Two, Code of Practice for Daylighting. London, BSI 1992

24 **Chartered Institution of Building Services Engineers**. CIBSE Applications Manual AM3 Condensing Boilers. London, CIBSE, 1989

25 **Chartered Institution of Building Services Engineers**. CIBSE Applications Manual AM1, Automatic Controls and their Implications for System Design. London, CIBSE, 1985

26 **Department of the Environment**. Saving Energy in Schools, Energy Consumption Guide 28. London, DOE, 1993

FURTHER READING

27 **Department of the Environment.** Energy efficiency in schools – local controls for heating and lighting, Good Practice Case Study 95. Garston, BRE, 1995

28 **Department of the Environment.** Drawing a winner. Energy efficient design of sports centres, Good Practice Guide 211. London, DOE, 1996

29 **Department for Education and Employment.** Broadsheet 27, Energy Efficient School Refurbishment – Three case studies.

30 **Department of the Environment.** Energy Saving in Schools, General Information Leaflet 13. London, DOE, 1995

31 **Department for Education and Employment.** Schools' Environmental Assessment Method (SEAM). *Building Bulletin 83*. London, HMSO, 1996

32 **Building Services Research and Information Association.** Environmental Code of Practice for Buildings and their Services. BSRIA, 1994

33 Energy in Balance, N. Howard, Building Services May 1991 p36-38

34 **Department for Education and Employment.** A guide to energy efficient refurbishment, maintenance and renewal in educational buildings series. *Building Bulletin 73*. London, HMSO, 1991. ISBN 0-11-270772-6

35 **Department for Education and Employment.** Area guidelines for schools. *Building Bulletin 82*. London, HMSO, 1996. ISBN 0-11-270921-4

Contacts for related information or services:

Chartered Institution of Building Services Engineers (CIBSE)
Delta House, 222 Balham High Road, London SW12 9BS. Tel 0181 675 5211. Fax 0181 675 5449

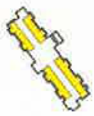
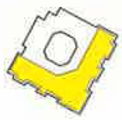
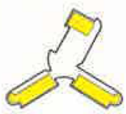
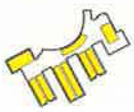
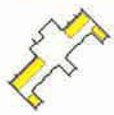
Royal Institute of British Architects (RIBA)
66 Portland Place, London W1N 4AD.
Tel 0171 580 5533. Fax 0171 255 1541

DOE ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

BRECSU, part of BRE, is an independent centre for information on energy efficiency in buildings, and manages the Department of the Environment's Energy Efficiency Best Practice programme. Referenced publications in the Best Practice series are available from BRECSU Enquiries Bureau (see back cover for contact details). Many other Best Practice programme publications are also available.

BRE documents are available from CRC Publications, telephone 0171 505 6622.

DfEE publications can be obtained from The Stationery Office Ltd.

	Hook Infants	St Peter's Primary	Farnborough Grange Junior	John Cabot CTC	Netley Abbey Infants	Looe Primary
Energy management system				■		
Condensing boiler				■		
Zoning				■		
Underfloor heating				■		
Localised water heating				■	■	■
Lighting control	■					
Shading			■	■		■
Atrium/rooflights	■	■				■
Draught lobby						■
Glazed street					■	
Thermal mass	Medium	Light	Mixed	Medium	Heavy	Heavy
Orientation/form Classrooms N						
Further reference	▼			▼	●	▲

▼ Building Bulletin 79 (Department for Education and Employment) ● General Information Leaflet 32 (DOE Best Practice programme)*

▲ General Information Leaflet 33 (DOE Best Practice programme)*

Contents

*General Information Leaflets available from BRECSU on request.

SCHOOL PREMISES REGULATIONS SUMMARY SHEET

The Education (School Premises) Regulations 1996, SI 1996 No 360 HMSO

Acoustics

Each room or other space in a school building shall have the acoustic conditions and the insulation against distribution by noise appropriate to its normal use.

Lighting

1 Each room or other space in a school building:
- shall have lighting appropriate to its normal use
- shall satisfy the requirements of paragraphs **2** to **4**.

2 Subject to paragraph **3**, the maintained illuminance of teaching accommodation shall be not less than 300 lux on the working plane.

3 In teaching accommodation where visually demanding tasks are carried out, provision shall be made for a maintained illuminance of not less than 500 lux on the working plane.

4 The glare index shall be limited to no more than 19.

Heating

1 Each room or other space in a school building shall have such system of heating, if any, as appropriate to its normal use.

2 Any such heating system shall be capable of maintaining (in the areas set out in column **1** of the table below) the air temperature shown opposite (in column **2** of the table), at a height of 0.5 m above floor level when the external air temperature is -1°C.

Area	Temperature
Areas where there is the normal level of physical activity associated with teaching, private study or examinations	18°C
Areas where there is a lower than normal level of physical activity because of sickness or physical disability including sick rooms and isolation rooms but not other sleeping accommodation	21°C
Areas where there is a higher than normal level of physical activity (for example arising out of physical education) and washrooms, sleeping accommodation and circulation spaces	15°C

3 Each room or other space which has a heating system shall, if the temperature during any period during which it is occupied would otherwise be below that appropriated to its normal use, be heated to a temperature which is so appropriate.

4 In a special school, nursery school or teaching accommodation used by a nursery class in a school, the surface temperature of any radiator, including exposed pipework, which is in a position where it may be touched by a pupil, shall not exceed 43°C.

Ventilation

1 All occupied areas in a school building shall have controllable ventilation at a minimum rate of three litres of fresh air per second for each of the maximum number of persons the area will accommodate.

2 All teaching accommodation, medical examination or treatment rooms, sick rooms, isolation rooms, sleeping and living accommodation shall also be capable of being ventilated at a minimum rate of eight litres of fresh air per second for each of the usual number of people in those areas when such areas are occupied.

3 All washrooms shall also be capable of being ventilated at a rate of at least six air changes an hour.

4 Adequate measures shall be taken to prevent condensation in, and remove noxious fumes from, every kitchen and other room in which there may be steam or fumes.

Water supplies

1 A school shall have a wholesome supply of water for domestic purposes including a supply of drinking water.

2 Water closets and urinals shall have an adequate supply of cold water and washbasins, sinks, baths and showers shall have an adequate supply of hot and cold water.

3 The temperature of hot water supplies to baths and showers shall not exceed 43°C.

Drainage

1 A school shall be provided with an adequate drainage system for hygienic purposes and the general disposal of waste water and surface water.

DfEE

Acoustics

Values for maximum generated noise level, maximum background noise level and minimum insulation level between similar rooms are given in the new guidelines.

Lighting

Daylight should be the main source of light in working areas except in special circumstances. Wherever possible a daylit space should have an average daylight factor of 4-5%, together with a daylight uniformity of not less than 0.4 if lit by side windows, and 0.7 if top lit.

The uniformity ratio equals the minimum daylight factor divided by the average daylight factor. The uniformity ratio (minimum/average maintained illuminance) of the electric lighting in teaching areas should be not less than 0.8 over the working area.

Teaching spaces should have views out, and it is recommended that a minimum glazed area of 20% of the internal elevation of the exterior wall be provided.

A maintained illuminance of 100 lux with a uniformity of 0.8 is recommended for corridors and stairs. Entrance halls, lobbies and waiting rooms require a higher illuminance of 200 lux.

Heating

The heating system should be capable of maintaining the air temperatures quoted in the 'School Premises Regulations'. It is desirable that any swing in temperature should be within ±2°C of these levels. The heating system should be provided with frost protection.

During the summer, when the heating system is not in operation, the recommended design temperature for all spaces should be 23°C with a swing of not more than ±4°C. It is undesirable for peak air temperatures to exceed 28°C during normal working hours but a higher temperature on 10 days during the summer term is considered a reasonable predictive risk.

Unvented hot water storage systems should comply with 'Building Regulations, Part G3, 1992'.

The air supply to and discharge of products of combustion from heat-producing appliances and the protection of the building from the appliances and their flue pipes and chimneys should comply with 'Building Regulations, Part J, 1990'.

Thermal performance

The recommended maximum values of average thermal transmittance coefficients of the building fabric in W/m²°C are shown in the table below:

	W/m²°C
Walls	0.4
Floor	0.4
Roof	0.3
Roof with a loft space	0.25
Doors, windows and rooflights	3.3

Vertical glazed areas (including clerestory or monitor lights) should not normally exceed an average of 40% of the internal elevation of the external wall. However, where a passive solar design strategy has been adopted the percentage glazing may exceed 40%.

In areas prone to breakages due to vandalism the replacement cost may justify the use of single glazing instead of double glazing. In this case the insulation of the rest of the building fabric should be increased to compensate.

Glazing on any facade should not normally be less than 20% of the exposed wall area.

Horizontal or near horizontal glazing should not normally exceed 20% of the roof area.

Rooflights should be double glazed and double glazing should be considered for all glazing and will probably be required for thermal comfort.

Ventilation

The heating system shall be capable of maintaining the required room air temperatures with the minimum average background ventilation of 3 litres per second of fresh air per person when the outside temperature is -1°C.

Spaces where noxious fumes may be generated will also need additional ventilation and may require the use of fume cupboards, which should be designed in accordance with 'DfEE Design Note 29' (to be revised).

All lavatory accommodation and changing areas in which at least 6 air changes per hour cannot be achieved on average by natural means should be mechanically ventilated and the air expelled from the building.

Water

Cold water storage capacity should not exceed 25 litres per occupant.

All water fittings should be of a type approved by the Water Research Council, and all installations should comply with the 'Model Water Supplies Byelaws'.

In order to reduce the risk of Legionella Pneumophilla, hot water storage temperatures should not be lower than 60°C. However for occupant safety, to reduce the risk of scalding, the School Premises Regulations specify that the temperature at point of use should not be above 43°C for baths and showers and where occupants are severely disabled. This may be achieved by thermostatic mixing at the point of use. It is also recommended that hot water supplies to washbasins in nursery and primary schools are limited to 43°C.

Particular attention should also be given to the provision of facilities to ensure the effective maintenance of systems as recommended in Chartered Institution of Building Services Engineers, Technical Memorandum, TM13.

Energy (carbon dioxide) rating

In the design of a new building the calculated Annual CO_2 Production Value should be below the top of band E of Figure 1 or 2 of the Department of Education and Employment's (DfEE) Building Bulletin 83, 'Schools Environmental Assessment Method (SEAM)', when the environmental standards in Sections B and C have been achieved.

The recommendations above are from the 'Guidelines for Environmental Design in Schools', the proposed replacement of Design Note 17, currently being drafted by the DfEE.

HOOK INFANTS AND JUNIOR SCHOOL, HAMPSHIRE

Hook Infants and Junior School

- Thermally medium-weight construction
- Atrium with controllable ventilation
- Automatic lighting controls
- Low maintenance

INTRODUCTION

Hook Infants and Junior School was enlarged and remodelled as part of a building and site rationalisation project in 1988 by Hampshire County Council. This Case Study illustrates the advantages of an integrated design approach, delivering tangible benefits to the form, fabric and services of the building.

The project has resulted in improved educational facilities by combining the infant and junior schools. All facilities are shared under one roof on a reduced site area.

DESIGN APPROACH

This was one of the first projects for which Hampshire County Council adopted an integrated approach to the maintenance and refurbishment of SCOLA system built schools. The design team took account of maintenance issues during the planning phase of the refurbishment project. This integrated approach resulted in an energy efficient building with low maintenance requirements.

SITE AND PLAN FORM

The original school building form was based on an H-plan footprint. By extending each leg of the H-plan along its north-west/south-east axis the teaching area has been increased.

Additional useful space has been created, in the form of two atria. These were constructed by adding a pitched glazed roof over the central section between the classrooms on each leg of the H-plan. The atria are heated and carpeted for comfort, and are used as teaching areas and as a general circulation zone between classrooms.

Heating in atria is not generally recommended unless the building is specifically designed to be used as a classroom space throughout the year and

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HOOK INFANTS AND JUNIOR SCHOOL, HAMPSHIRE

Central atrium takes advantage of solar gains to heat the area.

appropriate attention has been given to overall thermal insulation levels etc. Consequently, at Hook School, the realised energy consumption is comfortably below average for a school of its type.

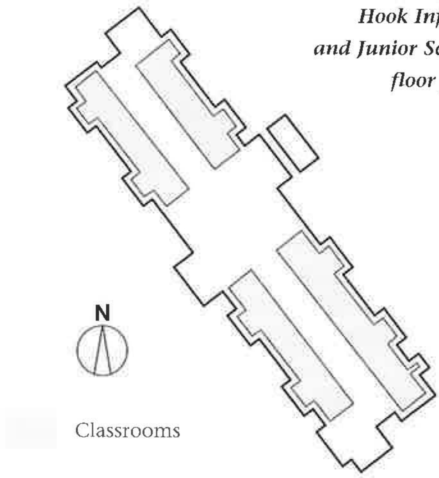
CONSTRUCTION AND BUILDING FABRIC

Both the refurbished and new-build parts of the building have been well insulated. The construction is thermally medium weight. The addition of carpet to the central atria has reduced the exposed thermal mass in these areas. During periods of high solar gain, controllable ventilation is provided by manually opening vents in the atrium roof.

Daylight enters classrooms through external windows and clerestory glazing facing on to the atria. Glare is reduced by opaque composite roof sheets positioned on the south-facing section of the atria.

SERVICES

The school is primarily heated by a gas-fired central heating system. Advantage is taken of solar gains to provide heat to the atria, although no provision has yet been made for adjacent classrooms to benefit from this heat. Automatic lighting controls have been installed as an energy saving feature in the school.



Hook Infants and Junior School floor plan

FURTHER READING

Department for Education and Employment Building Bulletin 79

ST PETER'S PRIMARY SCHOOL, COGGESHALL, ESSEX

St Peter's Primary School

- Lightweight construction
- Extensive use of glazing
- Rooflight
- Low energy

INTRODUCTION

St Peter's Primary School, Coggeshall, was designed by Essex County Architects, the in-house design team of Essex County Council. This Case Study illustrates the benefits achieved through an integrated design approach, resulting in an energy efficient school building with maximum advantage taken of available natural daylighting.

DESIGN APPROACH

The integrated design approach adopted for this new-build school involved the architects, head teacher and building services engineer at an early stage. This ensured that the building was not only energy efficient and comfortable, but also offered an environment conducive to the educational process.

The design team's priority was to minimise the building's energy requirements and maximise the daylighting to teaching areas.

SITE AND PLAN FORM

The design specification resulted in a single-storey compact building centred around a double height assembly hall. The sloping site led to a split-level design in which the open-plan classroom areas are located to the south-east and south-west of the hall.

The hall, administration and teaching areas are 1 m higher and located to the north. Circulation is along an L-shape corridor separating the two areas.

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ST PETER'S PRIMARY SCHOOL, COGGESHALL, ESSEX

Rooflights allow daylight to penetrate the building

CONSTRUCTION AND BUILDING FABRIC

The school building is of lightweight construction incorporating 100 mm insulation to the roof and external walls.

The building makes extensive use of glazing. Rooflights over the circulation areas and glazed internal walls enable daylight to penetrate deep into the building, thereby avoiding the poor daylighting characteristics which are often associated with compact buildings. The hall also benefits from daylight via a glazed pyramidal rooflight.

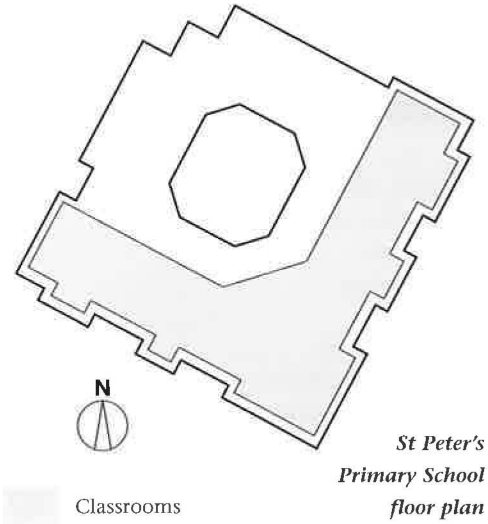
SERVICES

The space heating and kitchen hot water are supplied by two gas-fired boilers, incorporating optimum start and a weather compensator.

The heating system is controlled by a single wall-mounted thermostat, sited in the lobby adjacent to the school secretary's office. Thermostatic radiator valves are fitted to individual radiators and fan-coil heaters are positioned beneath classroom windows.

The fan-coil heaters incorporate an air recirculating mechanism, whereby warm air is drawn from the highest part of the room to lower levels to reduce stratification.

During the summer months, mechanical ventilation is used to extract warm air from high level in the circulation areas using four thermostatically controlled fans. The hall is similarly ventilated using manually controlled fans. Separate mechanical ventilation systems are used in the toilets and kitchens.



St Peter's Primary School floor plan

FARNBOROUGH GRANGE JUNIOR SCHOOL

Farnborough Grange Junior School

- Mixed thermal mass
- Highly glazed on the south-facing areas
- Overhangs and sun screens
- Low energy

INTRODUCTION

Farnborough Grange Junior School was developed as part of Hampshire County Council's programme of replacing existing schools with low-energy buildings. This Case Study illustrates the benefits achieved through an integrated design approach, involving architects and energy advisers.

DESIGN APPROACH

The school is centrally located in the community and was designed to sit comfortably in the surrounding landscape. The main hall is used after school hours by local community groups, so it was particularly important for the building to satisfy this occupancy pattern.

The design team's approach was to minimise heat loss and maximise solar benefits, while ensuring that the building was warm and welcoming.

SITE PLAN AND FORM

The Y-plan of the single-storey school (see plan diagram overleaf) allows the main teaching areas to face south in two identical wings, each comprising four classrooms and a tutorial room. The north-facing wing contains the main hall, kitchen, music room and ancillary areas. The plan allows daylighting and passive solar gain in the classrooms.

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FARNBOROUGH GRANGE JUNIOR SCHOOL

Overhangs restrict excessive solar gains and glare

CONSTRUCTION AND BUILDING FABRIC

All materials used within the building were chosen for their durability and environmental impact.

The building has high thermal mass to minimise heat loss on the north-facing walls. It also incorporates a lightweight, highly glazed construction to maximise solar gain on the south-facing areas. Excessive gains and glare are restricted by overhangs and sun screens.

External walls are insulated to the Building Regulations of 1990, with a higher level of insulation in the roof.

Daylighting is provided directly through windows and indirectly via the lower curved roof and clerestory. These provide uniform daylight throughout the classrooms.

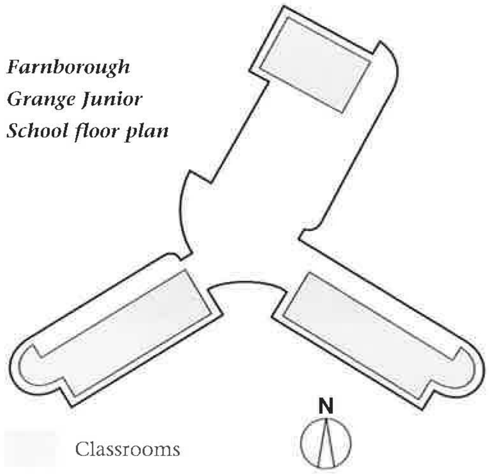
Natural ventilation of the classrooms is achieved through opening clerestory windows.

SERVICES

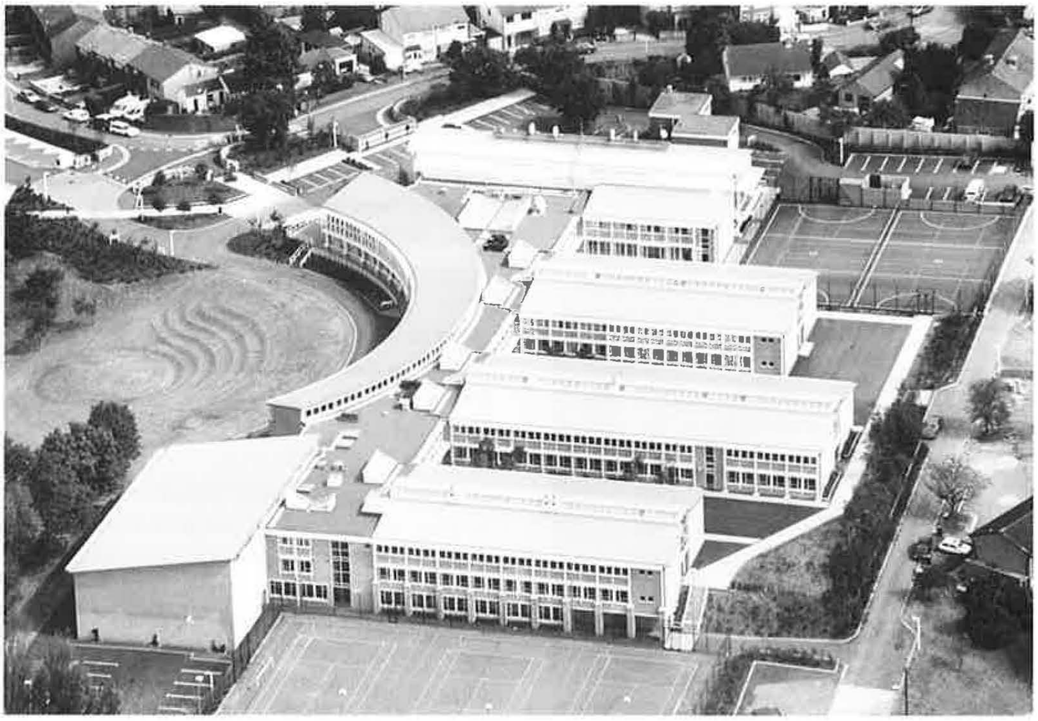
The services are designed for ease of operation by users. Space heating is provided by a wet radiator system with thermostatic radiator valves to allow individual control.

The plant room is located centrally, with the resultant benefit of reduced service runs.

Farnborough Grange Junior School floor plan



JOHN CABOT CTC, BRISTOL



John Cabot CTC

- Condensing boiler
- Zoned for energy efficient use
- Point-of-use electric water heaters
- Triphosphor lamps
- High-frequency control gear for lighting
- Underfloor heating system

INTRODUCTION

This city technology college (CTC), specialising in telecommunications, was built in 1993. The basic design brief was for an easily controlled energy efficient building with minimal environmental impact. However, a specific requirement was that the building itself should be an educational aid to assist the students in their studies.

This Case Study illustrates the approach adopted by the integrated design team comprising architects, building services engineers and college staff, together with the benefits achieved.

DESIGN APPROACH

To satisfy the brief, the use of daylighting and natural ventilation was targeted. The benefits of good daylighting was balanced against excessive heat loss through large glazing areas.

Wide use was made of computer modelling techniques to finalise the design.

SITE AND PLAN FORM

The college building comprises a number of predominantly two-storey buildings linked together by a crescent-shaped internal street. The layout is designed to provide both primary and secondary circulation routes, with areas for socialising. The three classroom wings are designed to maximise the use of daylight and natural ventilation.

CONSTRUCTION AND BUILDING FABRIC

John Cabot CTC is constructed using a steel superstructure and a brick envelope. Extensive external shading is used to achieve a balance between daylighting and limiting excessive solar gains. Computer models indicated where shading was necessary; the forms of shading employed include roof overhangs, external roller blinds, and internal venetian blinds.

This page forms part of Good Practice Guide 173 (GPG 173), 'Energy efficient design of new buildings and extensions – for schools and colleges', produced by BRECSU as part of the Department of the Environment's Energy Efficiency Best Practice programme. For further information on buildings-related topics contact: Enquiries Bureau, BRECSU, Building Research Establishment, Garston, Watford, WD2 7JR Tel 01923 664258 Fax 01923 664787 E-mail brecsuenq@bre.co.uk

JOHN CABOT CTC, BRISTOL

An internal street links the college's two-storey teaching buildings

A variety of ventilation mechanisms were developed to avoid build-up of internal gains. Natural ventilation was employed in the 7 m wide classrooms, air flow being induced by adjacent ventilating chimneys with extracts through louvres at roof level. Some ground floor areas are side ventilated by opening windows.

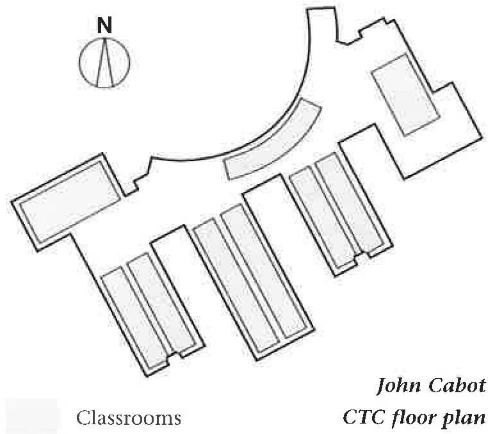
SERVICES

Space heating is provided by a high-efficiency condensing boiler and two standard gas-fired boilers operated by a BEMS. The system is zoned to allow flexibility, such as low occupancy and community use. Each classroom is on a separate heating circuit, controlled via a local heat station. To help satisfy the educational brief of the design, all plant is visible to students, to add to their knowledge of the various systems that contribute to the college's energy efficiency - and their comfort.

The main hall, dining hall and entrance area have an underfloor heating system, fed with low temperature heat from the condensing boiler circuit. A faster response time is required in the sports hall, so fan convectors provide a separate warm air heating system.

Direct gas-fired storage water heaters are provided in both the sports changing room and kitchen. Point-of-use electric water heaters are used in toilets and teaching areas.

Triphosphor lamps are used throughout the college for good colour rendering, and all luminaires have high-frequency control gear. The luminaires also have anti-glare louvres to provide the quality of light necessary for VDU work.



John Cabot CTC floor plan

FURTHER READING

Department for Education and Employment Building Bulletin 79

The Department of the Environment's Energy Efficiency Best Practice programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

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Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R&D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Introduction to Energy Efficiency: helps new energy managers understand the use and costs of heating, lighting etc.